Chip Tuning

Engine Management Tweaking

By Christian Tomanik

ctomanik@gmx.de

Fed up with your car’s sluggish performance? Want more power but can’t stand the sight of furry dice? Many motorists are turning to the ‘chip-tuning’ alternative to secretly unleash their car’s full potential.

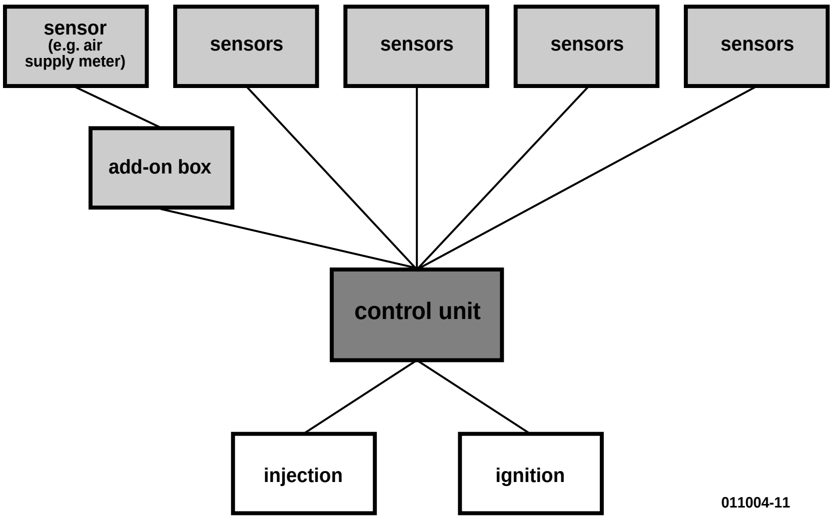


Figure 1. 'Add-on' box between the sensor and the Electronic Control Unit alters the readings from the airflow meter to increase fuel percentage.

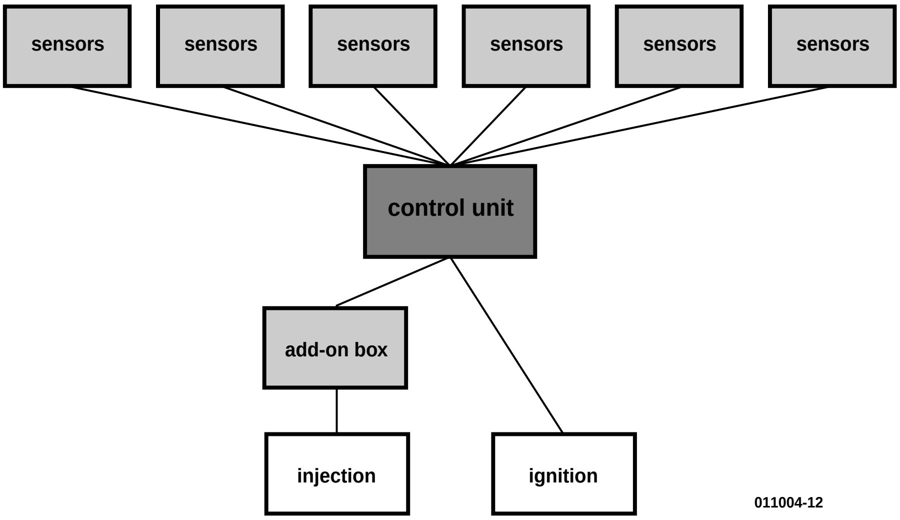


Figure 2. 'Add-on' box between the Electronic Control Unit and the fuel injector increases the injection period.

Buy a car these days and you can be sure that the engine will be controlled by an Engine Management System (EMS) containing a microprocessor in an Electronic Control Unit (ECU). The processor reads values of engine speed, inlet airflow, water temperature etc., and decides when to produce the ignition spark. The processor also controls any fuel injectors or turbochargers fitted to the engine. The engines performance is defined in a look-up table stored in an EPROM, so for a certain engine speed at a certain manifold pressure the spark advance figure is given in the look-up table or 'map'. Chip tuning or 're-mapping' involves changing the values stored in this map.

Most tuning companies suggest that chip-tuning can produce an improvement in power and torque of between 10 and 20 % for a basic engine but the increase can be more than 45 % for a turbocharged diesel engine.

Such staggering increases seem hardly credible — only a few years ago it would have been necessary to perform a top-end rebuild, perhaps slipping in a specialist camshaft and modifying the cylinder head but now the same effect can be achieved in a few hours with a simple software change to the motor's EMS. It also begs the question: why don't the manufacturers supply the engines already modified? In this article we hope to fill-in some of the background and look at the pros and cons of chip-tuning.

Modern manufacturing practices in the car industry mean that each new engine will be put through its paces on a test rig before being fitted to the vehicle. Here it undergoes fine-tuning to ensure that the car's performance conforms to its specification. Tolerances in the manufacturing process ensure that each engine produced will not have exactly the same performance as the next. The final phase of engine set-up will usually involve a certain amount of de-tuning to an average engine. This ensures that fewer engine units are rejected on the grounds of low performance and helps make the production process less wasteful. Chip tuning allows you to tap into this 'power reserve' by changing the engine characteristics.

Some manufacturers take the approach of developing a single high performance engine type which is fitted to their top-of-the-range models and then with a re-programming of the engine management software at the factory the same fire-breathing demon of an engine is turned into a lower revving, smoother and more fuel efficient pussy cat for use in lower-spec cars. These de-tuned engines offer greater potential power and torque gains when 'chipped'. Audi for example currently market at least four 2.7 litre models with a maximum quoted power output ranging from 230 to 380 bhp depending on model.

Turbo boosted engines (especially diesels) allow the boost pressure to be brought into the equation and give the greatest potential power gain. Some kits on the market allow boost pressure to be adjusted from a dashboard mounted control knob. It may sound a bit gimmicky but it will prolong engine life if boost pressure is set to minimum when the engine is cold (the time when most wear occurs) and only turned up once the engine is warmed up, just to give an extra kick when needed for overtaking.

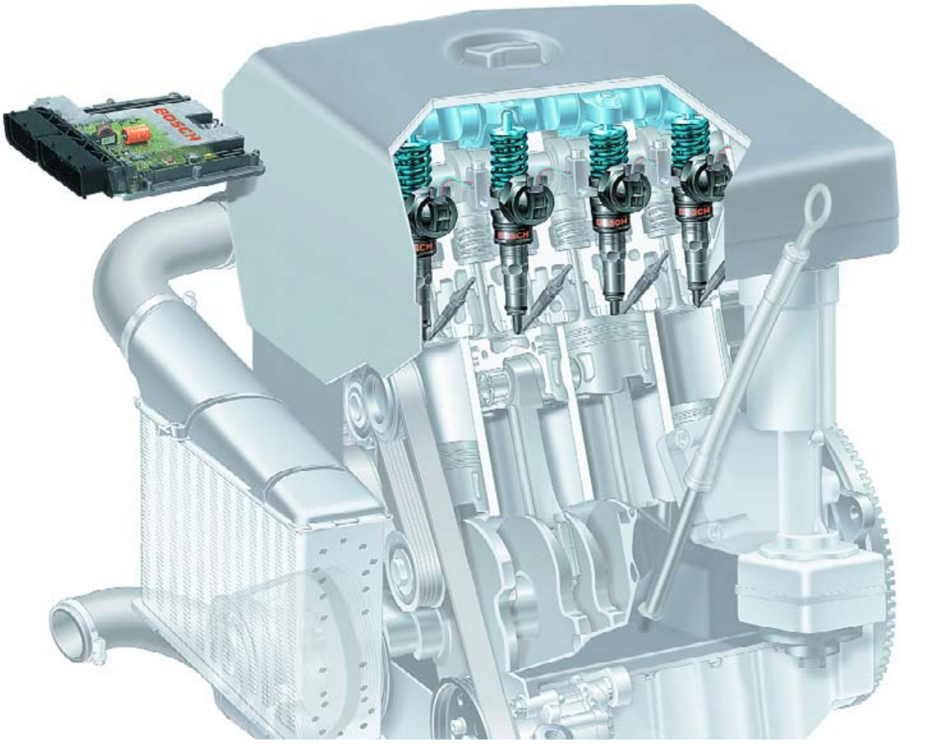


Figure 3. A favourite for chip-tuning is the modern turbo-charged, direct-injection diesel engine. Raising the boost pressure by 0.1 bar will give 10% more power after re-mapping. (Picture: Bosch)

Chip tuning and add-ons

You would expect the vehicle manufacturers to have complete documentation and all the tools necessary to analyse and modify the engine's characteristics, but this information is not generally available and few chip-tuning companies possess the necessary equipment to be able to read and re-map the ECU memory. A simpler form of chip tuning is available to get round this problem. An add-on tuning box is fitted in the wiring between the engine sensors and the ECU input. These boxes effectively have a scaling effect on the sensor values so that if, for example, the add-on box multiplies the values from the air input sensor (**Figure 1**) the processor will be fooled into thinking that more fuel is needed to keep the mixture correct. Alternatively, the box can be fitted between the ECU and the injector to increase the injection period (**Figure 2**). These add-on boxes are much simpler to fit and need little specialist knowledge to set up. In contrast, classical chip-tuning is much more complex and involves reading out the engine characteristics mapped in the EPROM and replacing them with modified values. This type of work is not easy for most mechanical workshops to perform because it involves knowledge of both hardware and software, so if you are considering a chip conversion it will be necessary to track down a specialist garage. Even then, there is no guarantee that the chip tuner knows what he is doing. Some less reputable operators favour the trial and error approach whereby the parameters are altered until a power increase is detected and then the tuning process is considered finished.

Experienced chip-tuners on the other hand use a professional Editor program to decode the ECU memory and also an engine simulation program to optimise and predict the effects of changes to the engine map. The process is labour intensive and requires a high level of skill.

Chip-tuning made easy?

Most people would expect the engine characteristics to be stored somewhere in an integrated controller/EPROM chip somewhere in the EMS of the car. In actual fact, they are almost invariably stored in a conventional EPROM plugged into a socket in the ECU.

The author had the opportunity to experience development of engine management electronics in both a conventional car production facility and also in the more rarefied atmosphere of competitive Motor Sport. This gave a good insight to the techniques of chip-tuning and the working practices of some tuning specialists. What this underlined is the importance of dealing with a reputable company. Very few tuning specialist have the resources to carry out the same sort of testing that vehicle manufacturers put their engines through. In the car industry, the engine control maps are not simply calculated from a computer simulation, they are optimised after an extensive cycle of test-bed development and test-driving on the track. By contrast, many chip tuners do not move far from their desk. Many calculate the offset values and simply re-program the map and test it on a rolling road to check for any change in the power output. The problem here is that it may produce an engine that has good performance only within a narrow range of engine speeds but runs unacceptably under other operating conditions. The missing ingredient is testing. Vehicle manufacturers invest a great deal of time and effort to ensure that the car runs just as well on the Saharan plains as it will on the foothills of the Himalayas. It is just not possible for a small tuning firm with limited resources to carry out the same range of testing for chip-tuned cars. Apart from this, a great deal of investment in personnel is necessary to build up experience and training before a tuner can reach any level of competence.

And on the downside…

In principle it is relatively easy to increase an engine's power output: squirt more fuel/air mixture into the cylinder and you get a bigger bang and hence more power and torque. One of the more obvious side effects of this modification is that fuel consumption will suffer. This form of tuning will not improve the engine efficiency or fuel consumption although many of the chip manufacturers claim better fuel economy for the same driving style.

Bigger bangs will obviously put more mechanical stress on the engine and drive train components and will lead to a reduction in their lifespan. Increasing the fuel/air mixture is also not such a simple procedure because if we keep the same injectors there will be a limit to the maximum fuel flow rate, so to produce a greater fuel volume it is necessary to increase the input cycle injection period. This extended injection period can cause problems in the engine. Especially in a diesel motor under load (turbocharged), excess fuel vapour can condense on the cylinder walls, leading to incomplete combustion and a build-up of soot in the cylinder head (not to mention the clouds of black smoke). This has the effect of increasing engine temperature and can cause the piston head to overheat. Temperatures in excess of 400 °C will cause the protective oil film to break down and produce excessive cylinder and piston wear. It is often necessary to fit a larger radiator or oil cooler to reduce the possibility of overheating.

If we now turn to the paperwork you should be aware that if the car is still under warranty, any tuning or engine modifications will render the warranty void. It will also be necessary to tell your insurance company. Any performance modifications to the car will mean that it no longer complies to its standard specification and you can be sure when it comes to the crunch your policy will be void unless they have been informed.

Add-on boxes

Add-on performance enhancing boxes are not true re-mapping devices because they do not alter the stored engine characteristics; they simply add an offset to the signals from the ECU and sensors but are never the less popular because of their ease of installation.

As we mentioned earlier, there are basically two types of add-on boxes. The original concept was that the box sits between the airflow sensor and the ECU and fools the ECU into injecting more fuel by scaling-up the measured airflow values. More recently manufacturers have been offering longer warranties on their cars and are anxious to prevent any possible damage caused by this type of tuning during the warranty lifetime. Some manufacturers are therefore introducing a reality check in the software of the ECU. This means that all the input sensor values are first checked to ensure they fall within accepted limits and any measurements outside these limits are ignored and a warning indicator lights on the dashboard. A diagnostic failure code will also be stored in the processor memory. The sensor signal is analogue, so the add-on boxes need not contain any form of processor, in fact just a couple of resistors and capacitors are all that is necessary to generate an offset.

The second type of box was developed to get round this restriction. This box is digital and sits between the ECU and injector. It works by intercepting and lengthening the fuel injection signal to the injectors. We have already touched on some of the possible disadvantages of this type of tuning.

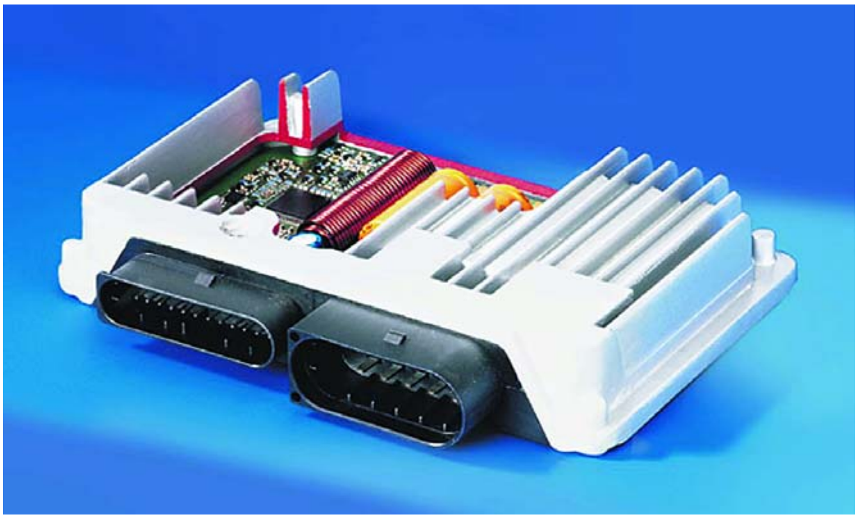


Figure 4. A Siemens variable valve controller fitted to BMW engines (picture: Siemens).

What you can expect

Generally speaking, if you take a standard normally aspirated (non turbo) production motor and fit an ‘off-the-shelf’ chip-tuning package you can expect a power (and torque) increase in the range of 10 to 15 %. These chip-tuning kits are designed specifically for one type of car/engine combination and can be fitted without any need for further adjustments. To extract more power the car needs to be individually adjusted and fine-tuned using a dynamometer and rolling road set-up where the engine mapping can be optimised. This method is more labour intensive but you can expect up to 35% improvement. Turbo diesels are the favourite and can be tweaked beyond 50%. Further power increases are unlikely without resorting to traditional tuning techniques.

Ex-works Chip tuning?

As we’ve already mentioned, chip tuning gives a standard vehicle the performance of a sports car but if you take a closer look under the bonnet of a production sports car you will notice that it is not just a different chip that distinguishes the car from the standard model. There will most probably be improvements to other systems in the car like the brakes and suspension, bigger radiator, different turbo and injectors. So buying a performance car from the manufacturer provides an integrated package.

In Germany where chip-tuning is more mainstream than here in the UK, there is one manufacturer of specialist diesel tuning equipment whose products are endorsed by the car company Ford. This means that the full range of products from the company ‘WOLF concept’ (including chips) can be fitted through the normal Ford dealership. The products are on the whole a little expensive but have the advantage that the vehicle’s warranty will not be affected.

Don’t try this at home

Any curious Electronics Engineer is probably thinking at this point that it would make an enjoyable evening’s exercise to break out the EPROM programmer and re-map the family runabouts engine on the kitchen table but unfortunately it's not really something to be recommended unless you have access to a test bed and a spare engine (or two). If you are considering modifying your car, it is far better to spend your time tracking down a reputable specialist. Check out any guarantee conditions and talk to people who have already made the conversion. Get a quote from an insurance company before you invest in the tuning just to check if you really can afford it. Make sure that the tuning company can guarantee its promised power increase (dynamometer evidence) and check liability for any consequent engine damage. The size of the tuning company is less important than their experience, maybe they have a demo car that you can try out before you make any financial commitment. Ask if they will put you in touch with previous customers who have already made the conversion, a reputable firm will have nothing to hide.

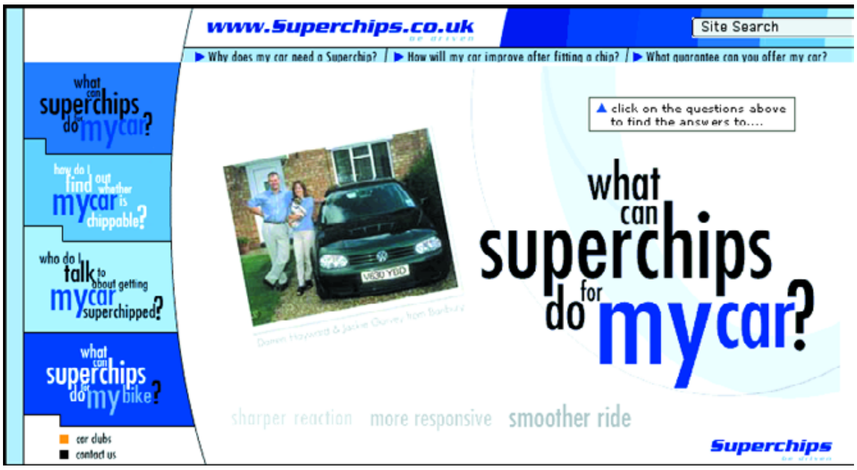
As a final thought, chip-tuning is in its infancy in the UK, the second-hand market will have only a very small percentage of vehicles that have been 'chipped'. The manufacturers of these kits emphasise that a re-mapped engine will not be detected using normal servicing diagnostics and the engine can be easily converted back to standard tune when the time comes to sell the car on. The big question for any potential second hand car buyer in the future will be; would you want to buy a car that has been chipped? If not, how can you be sure that any car has not been chipped?

Internet sites

As ever, the Internet offers useful information and contacts for any potential chip-tuning fan. Van Aaken are a well respected company specialising in mechanical and electronic tuning aids. They also supply the EPROM emulators that allow tuning garages to connect a PC to the vehicles EMS. Based at the Transport Research Laboratory in Berkshire you can find them at www.vanaaken.com. Motorsport Developments (www.motorsport-developments. co.uk) are a company fitting EVO chips. These re-mapped EPROMS replace the standard chip. They have a dealership across the UK and tuning the engine involves extensive road testing. Tuning specialist BBR fit the Star*chip re-mapped memory and can be found at www.bbrgti.demon.co.uk. Superchips (www.superchips.co.uk) have been in business for some 15 years and offer re-mapping and a seven-day money back guarantee (less fitting costs). They have an extensive dealership network throughout the UK.

Remember, if you do decide to modify your engine you can also go ahead and fit the In Car Entertainment system and furry dice but neither are obligatory...

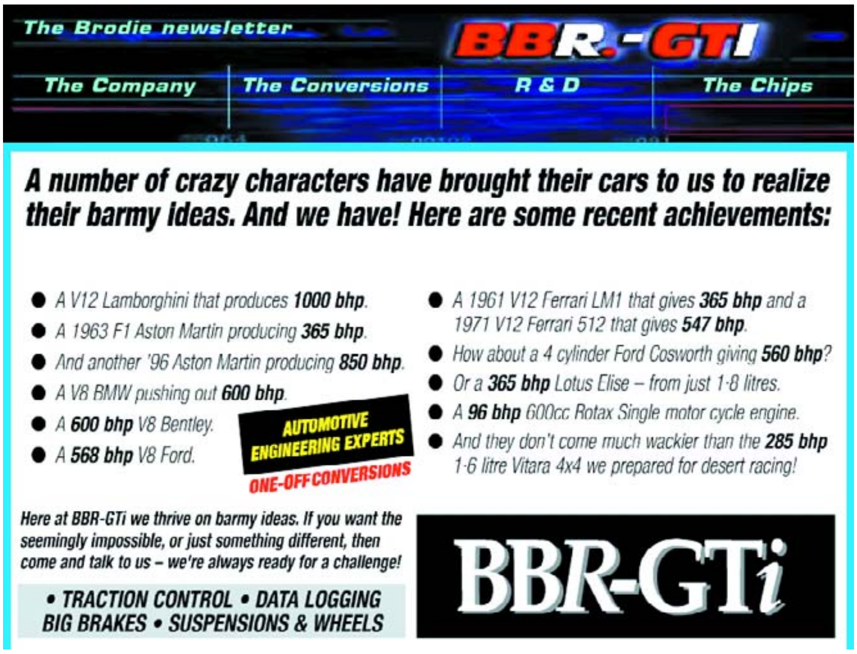
(011004-1)


www.Superchips.co.uk
be driven
Site Search
▶ Why does my car need a Superchip?
▶ How will my car improve after fitting a chip?
▶ What guarantee can you offer my car?
what can superchips do for my car?
how do I find out whether my car is chippable?
who do I talk to about getting my car superchipped?
what can superchips do for my bike?
car clubs
contact us
Darren Hayward & Jackie Garvey from Banbury
V830 YBD
Superchips
be driven

▲ click on the questions above to find the answers to....

what can superchips do for my car?

sharper reaction more responsive smoother ride

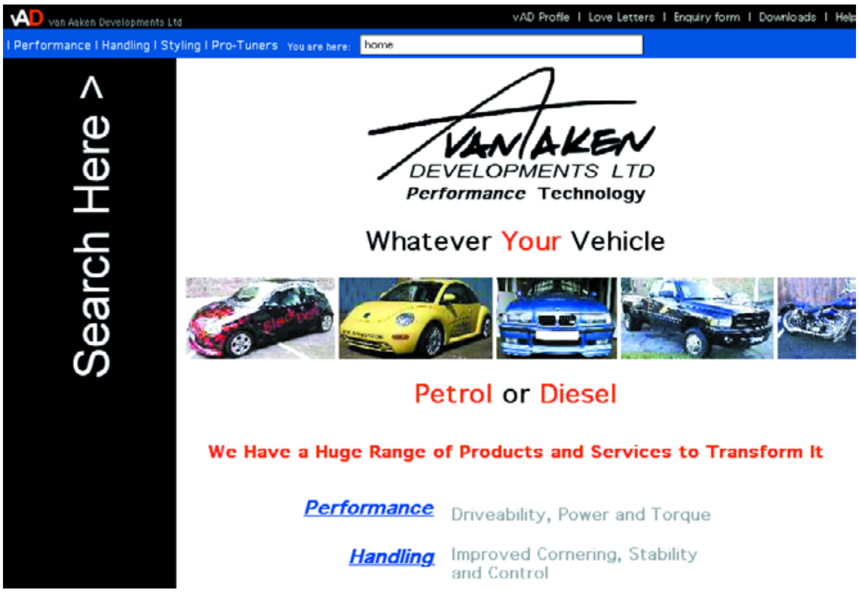


A number of crazy characters have brought their cars to us to realize their barmy ideas. And we have! Here are some recent achievements:

- A V12 Lamborghini that produces **1000 bhp**.
- A 1963 F1 Aston Martin producing **365 bhp**.
- And another '96 Aston Martin producing **850 bhp**.
- A V8 BMW pushing out **600 bhp**.
- A **600 bhp** V8 Bentley.
- A **568 bhp** V8 Ford.
- A 1961 V12 Ferrari LM1 that gives **365 bhp** and a 1971 V12 Ferrari 512 that gives **547 bhp**.
- How about a 4 cylinder Ford Cosworth giving **560 bhp**?
- Or a **365 bhp** Lotus Elise – from just 1·8 litres.
- A **96 bhp** 600cc Rotax Single motor cycle engine.
- And they don't come much wackier than the **285 bhp** 1·6 litre Vitara 4x4 we prepared for desert racing!

Here at BBR-GTi we thrive on barmy ideas. If you want the seemingly impossible, or just something different, then come and talk to us – we're always ready for a challenge!

• TRACTION CONTROL • DATA LOGGING
BIG BRAKES • SUSPENSIONS & WHEELS


vAD van Aaken Developments Ltd
vAD Profile I Love Letters I Enquiry form I Downloads I Help
I Performance I Handling I Styling I Pro-Tuners
You are here:
home
Search Here >
VAN AAKEN
DEVELOPMENTS LTD
Performance Technology

Whatever Your Vehicle

Petrol or Diesel

We Have a Huge Range of Products and Services to Transform It

Performance Driveability, Power and Torque

Handling Improved Cornering, Stability and Control